

WHAT IS CLAIMED IS:

1. A method for fabricating a semiconductor device having a ferroelectric capacitor in which a lower electrode, a ferroelectric thin film constructed of at least three layers, and an upper electrode are successively laminated on a substrate, comprising the steps of:

crystallizing an intermediate layer between a lowermost layer and an uppermost layer among the layers of the ferroelectric thin film by performing heat treatment for the intermediate layer at a first temperature for a first setting time; and

crystallizing at least one of the lowermost layer and the uppermost layer by performing heat treatment at a second temperature lower than the first temperature.

2. A semiconductor device fabricating method as claimed in claim 1, wherein

both the lowermost layer and the uppermost layer are crystallized by performing heat treatment at the second temperature.

3. A semiconductor device fabricating method as claimed in claim 2, wherein

a heat treatment time of the lowermost layer and the uppermost layer of the ferroelectric thin film is the first setting time.

4. A semiconductor device fabricating method as

claimed in claim 1, wherein

the lowermost layer is crystallized by performing heat treatment at the second temperature, and

the uppermost layer is crystallized by performing heat treatment for a second setting time shorter than the first setting time at the first temperature.

5. A semiconductor device fabricating method as claimed in claim 4, wherein

a heat treatment time for crystallizing the lowermost layer is the first setting time, and

a heat treatment temperature for crystallizing the uppermost layer is the first temperature.

6. A semiconductor device fabricating method as claimed in claim 1, wherein

the lowermost layer is crystallized by performing heat treatment for a second setting time shorter than the first setting time, and

the uppermost layer is crystallized by performing heat treatment at the second temperature.

7. A semiconductor device fabricating method as claimed in claim 6, wherein

a heat treatment temperature for crystallizing the lowermost layer is the first temperature, and

a heat treatment time for crystallizing the uppermost layer is the first setting time.

8. A method for fabricating a semiconductor device having a ferroelectric capacitor in which a lower electrode, a ferroelectric thin film constructed of at least three layers, and an upper electrode are successively laminated on a substrate, comprising the steps of:

crystallizing an intermediate layer between a lowermost layer and an uppermost layer among the layers of the ferroelectric thin film by performing heat treatment for the intermediate layer at a first temperature for a first setting time; and

crystallizing at least one of the lowermost layer and the uppermost layer by performing heat treatment at the first temperature or a second temperature lower than the first temperature for a second setting time shorter than the first setting time.

9. A semiconductor device fabricating method as claimed in claim 8, wherein

both the lowermost layer and the uppermost layer are crystallized by performing heat treatment for the second setting time.

10. A semiconductor device fabricating method as claimed in claim 9, wherein

a heat treatment temperature of the lowermost layer and the uppermost layer is the first temperature.

11. A semiconductor device fabricating method as

claimed in claim 1, wherein

the first temperature is a temperature being higher than 700°C and not higher than 800°C.

12. A semiconductor device fabricating method as
5 claimed in claim 8, wherein

the first temperature is a temperature being higher than 700°C and not higher than 800°C.

13. A semiconductor device fabricating method as
claimed in claim 1, wherein

10 the second temperature is within a range of 600°C to 700°C.

14. A semiconductor device fabricating method as
claimed in claim 8, wherein

15 the second temperature is within a range of 600°C to 700°C.

15. A semiconductor device fabricating method as
claimed in claim 1, wherein

the first setting time is longer than 10 minutes and not longer than 60 minutes.

20 16. A semiconductor device fabricating method as
claimed in claim 8, wherein

the first setting time is longer than 10 minutes and not longer than 60 minutes.

17. A semiconductor device fabricating method as
25 claimed in claims 4, wherein

the second setting time is within a range of five minutes to 10 minutes.

18. A semiconductor device fabricating method as claimed in claims 4, wherein

5 the second setting time is within a range of five minutes to 10 minutes.

19. A semiconductor device fabricating method as claimed in claim 1, wherein

10 the ferroelectric thin film is a ferroelectric substance of a Bi layer structure.

20. A semiconductor device fabricating method as claimed in claim 1, wherein

the ferroelectric thin film is formed by coating.

21. A semiconductor device fabricating method as claimed in claim 1, wherein

15 a film forming method of the ferroelectric thin film is an LSMCD method.

22. A semiconductor device fabricating method as claimed in claim 21, wherein

20 the intermediate layer is crystallized by repeating processes for performing deposition and tentative baking at a third temperature a plurality of times and performing heat treatment at the first temperature for the first setting time.

25 23. A semiconductor device having a ferroelectric

capacitor comprising:

a lower electrode laminated on a substrate;

a ferroelectric thin film laminated on the lower electrode and constructed of at least three layers including a lowermost layer, an uppermost layer and an intermediate layer located between the lowermost layer and the uppermost layer; and

an upper electrode laminated on the ferroelectric thin film,

wherein a crystal grain of at least one of the lowermost layer and the uppermost layer is smaller than a crystal grain of the intermediate layer.

24. A semiconductor device as claimed in claim 23, wherein

a crystal grain of the lowermost layer and a crystal grain of the uppermost layer is smaller than a crystal grain of the intermediate layer.

25. A method for fabricating a semiconductor device having a ferroelectric capacitor in which a lower electrode, a ferroelectric thin film constructed of at least three layers, and an upper electrode are successively laminated on a substrate, comprising the step of:

crystallizing the lowermost layer of the ferroelectric thin film by laser annealing.

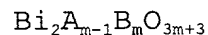
26. A method for fabricating a semiconductor device

having a ferroelectric capacitor in which a lower electrode, a ferroelectric thin film constructed of at least three layers, and an upper electrode are successively laminated on a substrate, comprising the step of:

5 crystallizing the lowermost layer of the ferroelectric thin film by rapid thermal annealing with infrared ray heating.

27. A semiconductor device fabricating method as claimed in claim 25 or 26, wherein

10 the ferroelectric thin film is made of a material expressed by:



where A represents one selected from a group consisting of Na, K, Pb, Ca, Sr, Ba and Bi,

15 B represents one selected from a group consisting of Fe, Ti, Nb, Ta, W and Mo, and

m represents a natural number.

28. A semiconductor device having a ferroelectric capacitor comprising:

20 a lower electrode laminated on a substrate;

 a ferroelectric thin film laminated on the lower electrode, constructed of at least three layers including a lowermost layer, a uppermost layer and an intermediate layer located between the lowermost layer and the uppermost layer; and

25

an upper electrode laminated on the ferroelectric thin film,

wherein

a crystalline nucleus density of the lowermost
5 layer is higher than those of other layers than the lowermost layer.